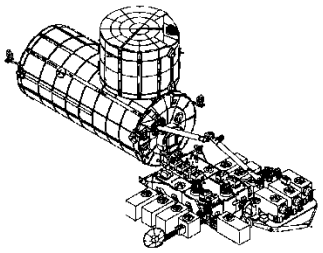
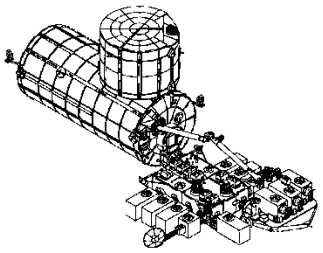


JAXA's Countermeasure Technology R &D

Hiroshi Ohshima

JAXA



JAXA's Countermeasure Technology R &D

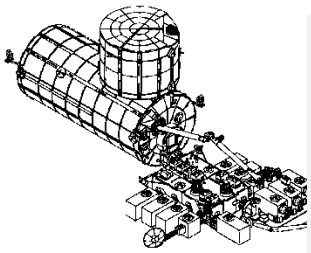
1) Onboard studies
   - JAXA Holter ECG

   (- Bisphosphonate study, collaboration between NASA and JAXA)

2) Selected by international AO (2010)
   - Hybrid training
   - Artificial gravity with ergometric exercise

3) CMT candidate
   - KAATSU training

4) Related Items
   - Space Gym Suit



JAXA Holter ECG

JAXA Holter ECG System is used for Biological Rhythms experiment to monitor cardiovascular and autonomic function of station astronauts.

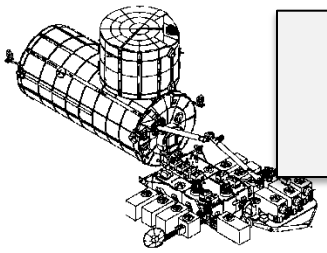
The system is the commercial medical equipment by Fukuda Denshi.

ECG
- channels: 2ch , 3ch
- Recording: 24hours
- Sampling Frequency: 125Hz

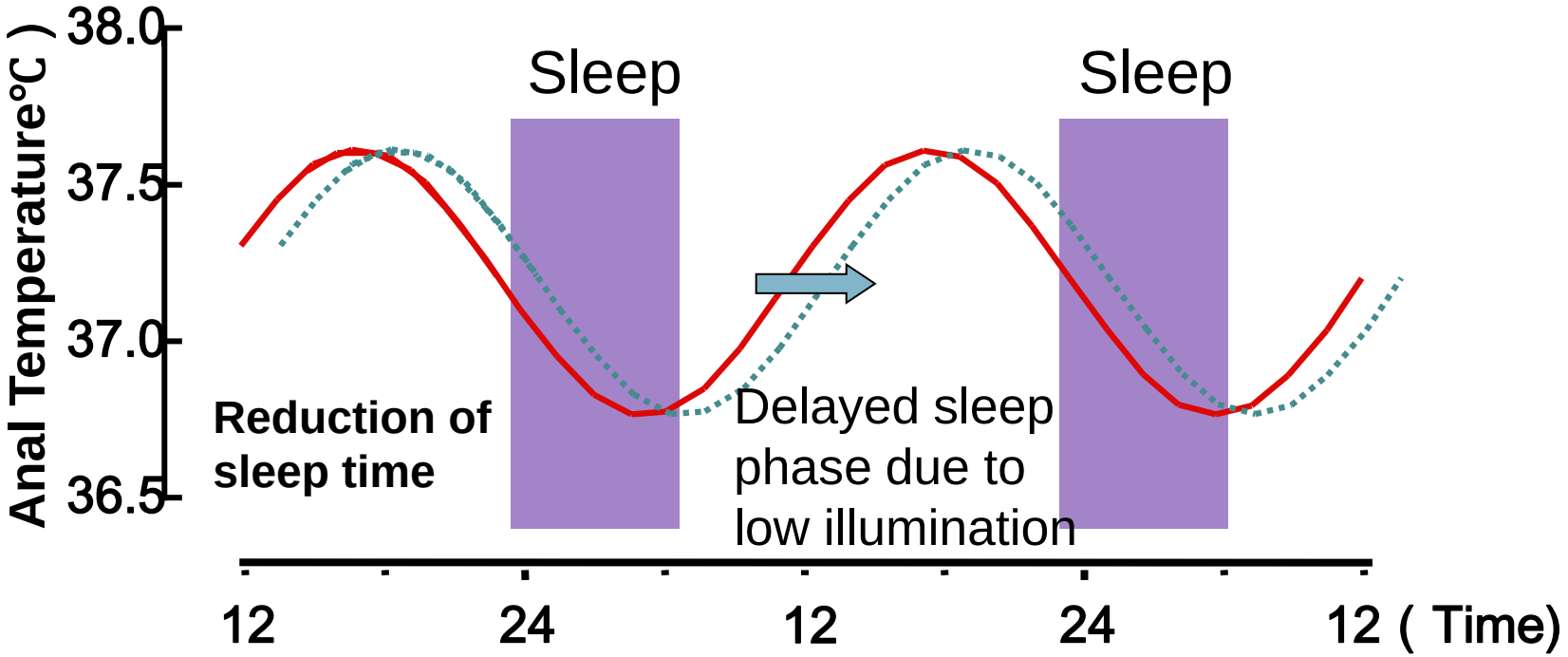
Recorder
- (W)65 X (H)62 X (D) 18 mm
- 78 g
- AAA Alkaline Battery x1

Components
- Multi Media Card 64MB
- Electrode

Software
- SCM-510 Holter Software



Change in Biological Rhythms

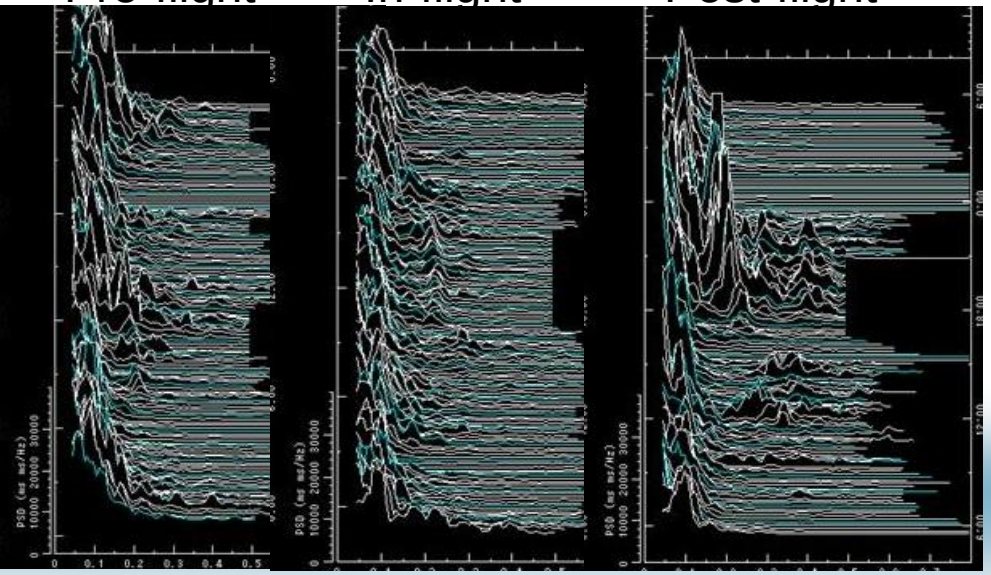


Cardiovascular reconditioning and biological rhythm disruption are induced by space flight and living in south pole, and they are closely related to autonomic function.

(Gundel A, 1997, Bhattacharyya M, et al, 2008)

24 hours ECG to monitor
1) Arrhythmia
2) ST change
3) Autonomic function
for space flight and antarcttic mission

Pre-flight In-flight Post-flight



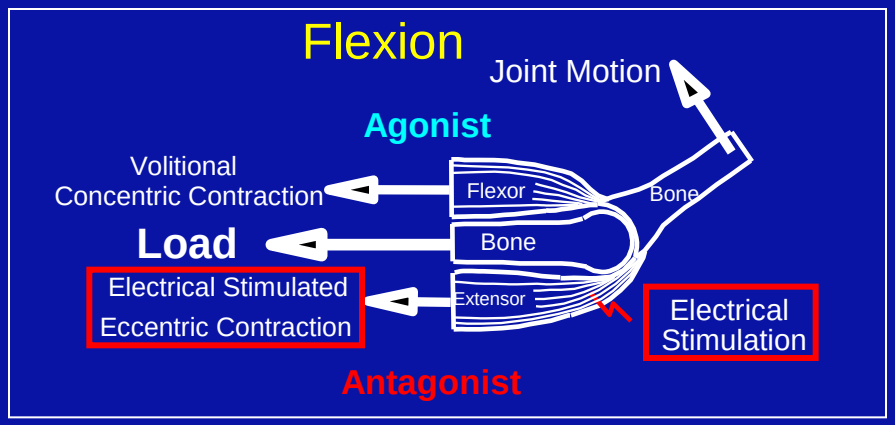
LF, HF: HRV spectrum

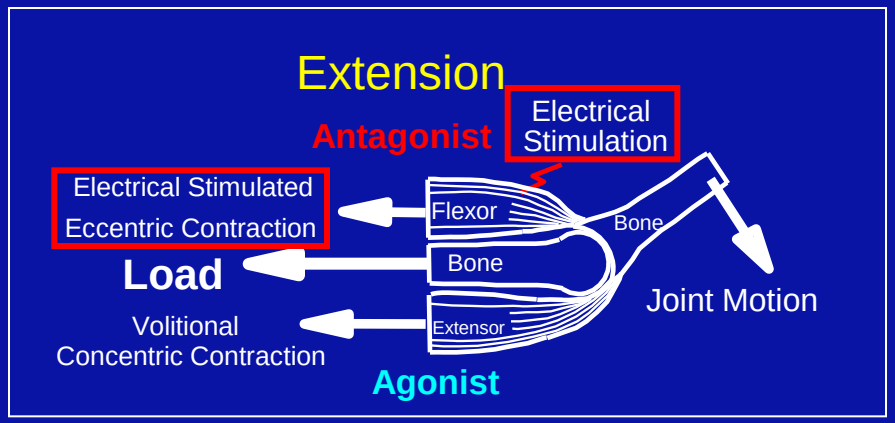
Monitoring for Japanese wintering party in the Antarctic

Collaboration with
Japan National Polar Research Institute

Hybrid Exercise

utilizing the force generated by an electrically stimulated antagonist to resist the motion of a volitionally contracting agonist





Concept

Dumbbell-like exercise is possible without dumbbell

⇓

Dumbbell-like exercise is possible in microgravity

(from Prof. Shiba, Kurume University, JAPAN)

Jpn patent 3026007. 2000 Jan 28.
US patent 6,456,885 B1. 2002 Sept 24.
Yanagi T et al: Archives of PM & R, 2003.

Upper Extremity

1) Hybrid ex group n=6
2) Isotonic exercise group (IE) group n=6
3) Electrical stimulation (ES) group n=6

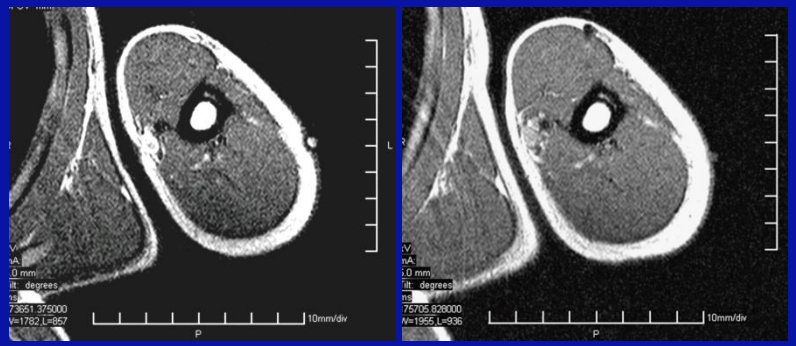
Exercise Program

Hybrid and ES Groups
8 weeks
3 times a week (Monday, Wednesday, Friday)
10sets/day (1 set: 45 deg/sec elbow curl 10 times)
15 min 40 sec including 1 min rest between sets
6 min 40 sec without rest interval

Stimulation electric current
80% of maximal comfortable electric current
(20-25% MVC of isometric contraction)

Isotonic exercise
40% MVC (dumbbell)

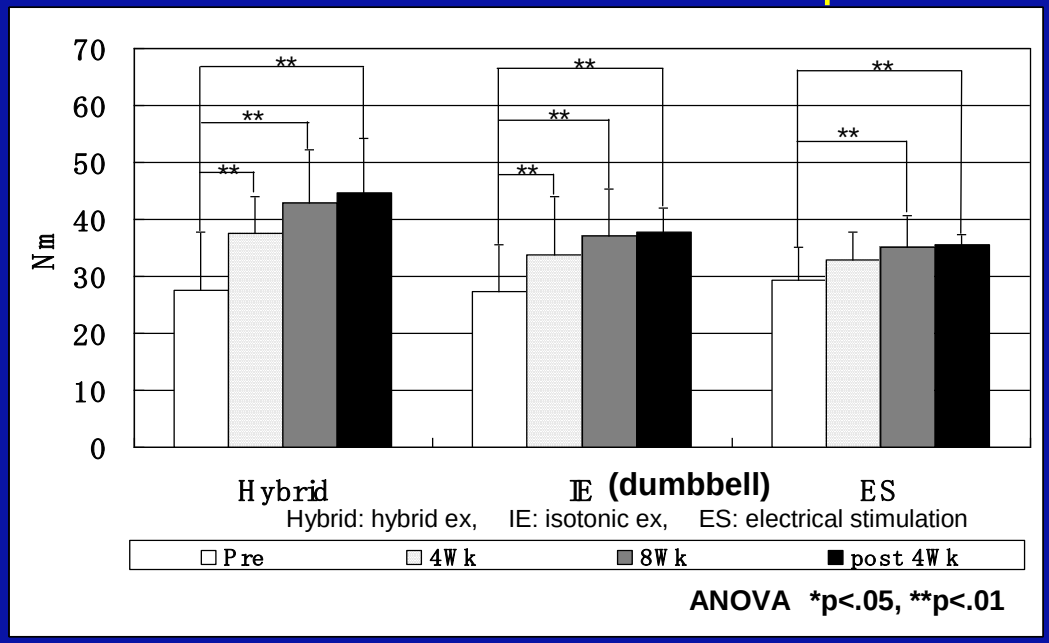
Cross section of upper arm



Pre 8Wks

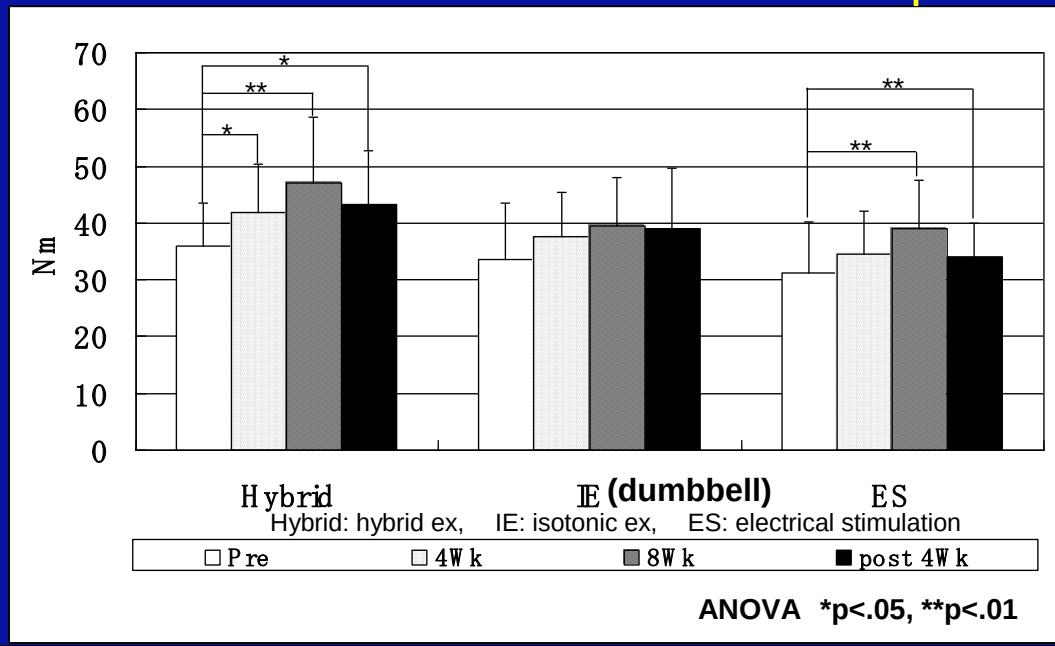
(from Prof. Shiba, Kurume University, JAPAN)

Isometric elbow flexion torque



ANOVA *p<.05, **p<.01

Isometric elbow extension torque



ANOVA *p<.05, **p<.01

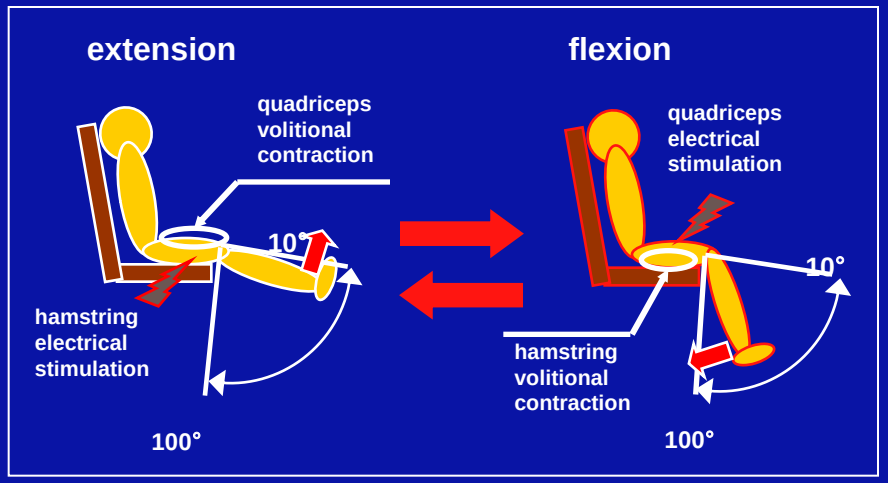
Lower Extremity

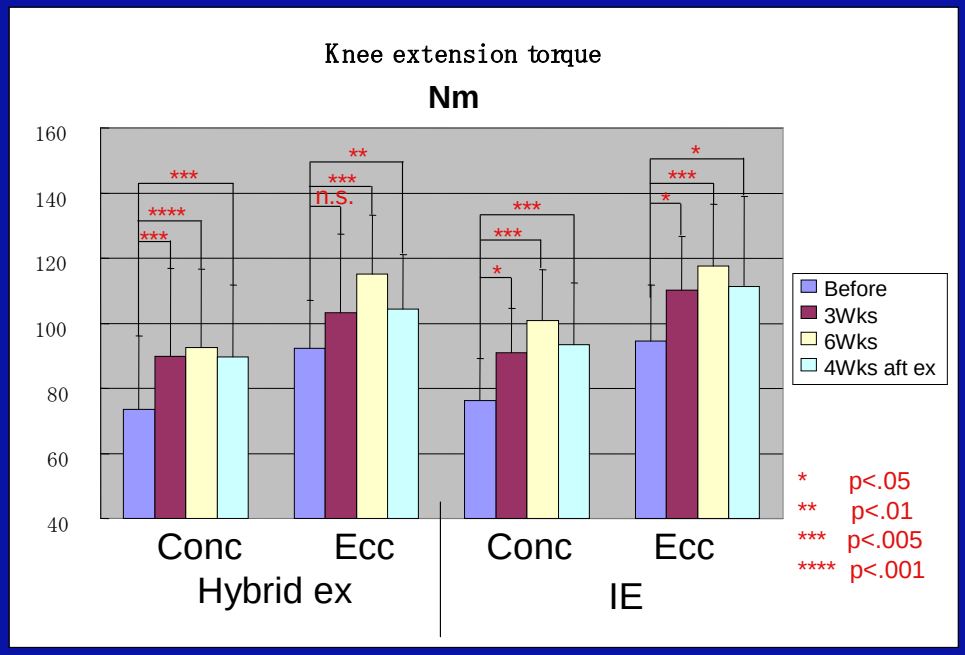
1) Hybrid ex group n=12
2) Isotonic exercise group (IE) group n=12

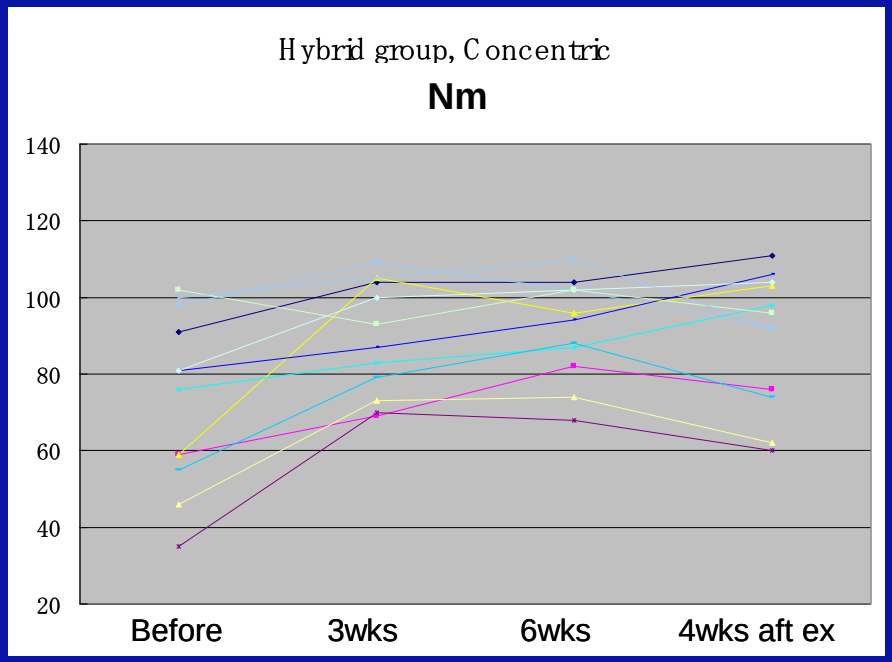
Exercise Program
Hybrid Group_
6 weeks
3 times a week (Monday, Wednesday, Friday)
10 sets/day (1 set: 45 deg/sec knee flx & ext 10 times)
15 min 40 sec including 1 min rest between sets
6 min 40 sec without rest interval
3 min 20 sec stimulation in each muscle

Stimulation electric current
80% of maximal comfortable electric current
(20-25% MVC of isometric contraction)

Isotonic Group
40% MVC



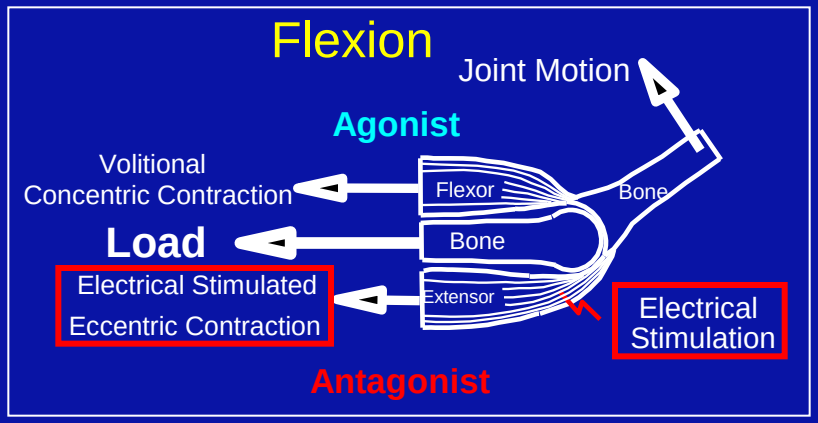




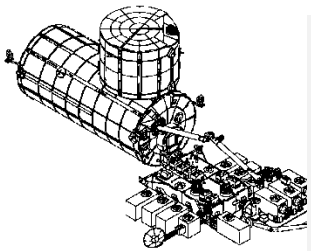
(from Prof. Shiba, Kurume University, JAPAN)

Hybrid Training

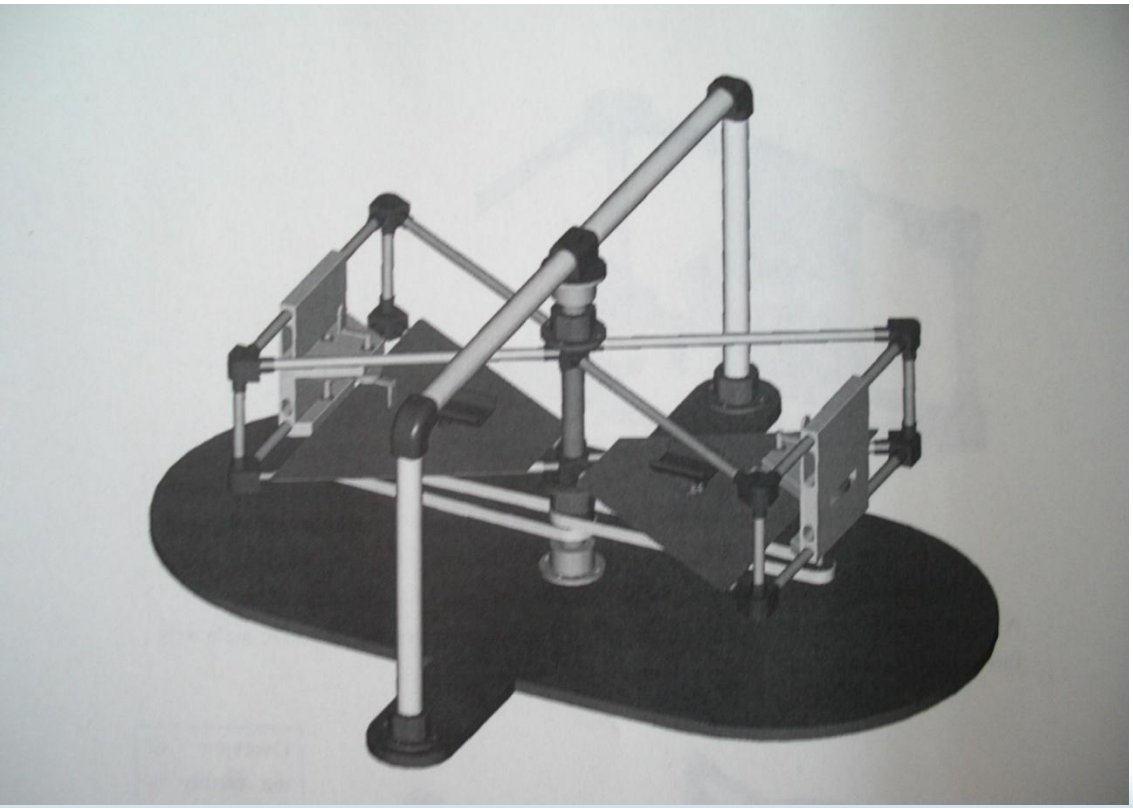
1. **Simultaneous exercise of both agonist & antagonist.**
2. **Deep layers of muscle can be activated by volitional contraction.**
3. **Electrically stimulated eccentric contraction produces 50% more tension than that produced by concentric with the same electric current.**
4. **Longitudinal loads are applied to bone.**



(from Prof. Shiba, Kurume University, JAPAN)



Artificial gravity with ergometric exercise



- **Dr.Iwase (PI) and international team**
- **The most challenging proposal**
- **Selected by international AO in 2010 (ISLSWG)**
- **Need international coorporation**

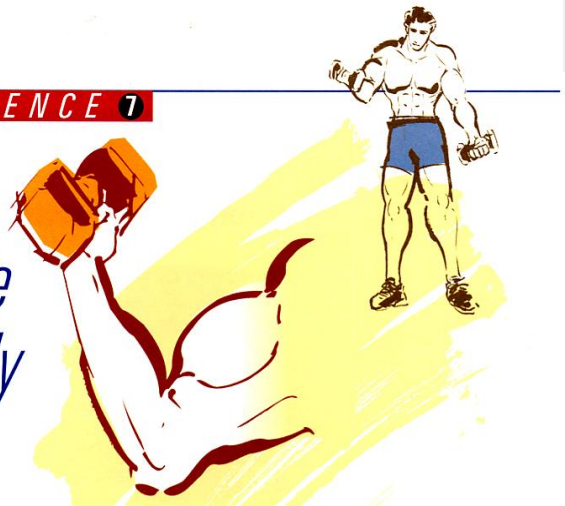
Future KAATSU Training as CMT Candidate

Ishii, N,: Innovation, No.29, 2001

SPORT Becomes SCIENCE 7

Light Weights Increase Muscle Strength Rapidly

Resistance-exercise training with vascular occlusion



Increasing muscle strength is an important challenge for athletes. Because it is commonly thought that effective strength training requires much time and pain, a revolutionary new training method is attracting attention: one that obtains results in dramatically shorter time and using much lighter

to muscle contractions create repeated cycles of extreme blood-flow restriction in the muscle tissue followed by excessive blood flow. A type of active oxygen formed during the periods of excessive blood flow promotes muscle thickening and creation of new blood vessel tissue in the muscles.

flow restriction in the muscle reinforces mechanism (1) and hindering the discharge of lactic acid and other metabolites enhances the action of mechanism (2). As no heavy weights are lifted, this training method shows promise for post-injury rehabilitation and for maintaining muscle strength in old peo-

Resistance Exercise with vascular occlusion

(“KAATS” training ™ patented by Sato)

Specially designed pressure tourniquet

Elbow flexion exercise

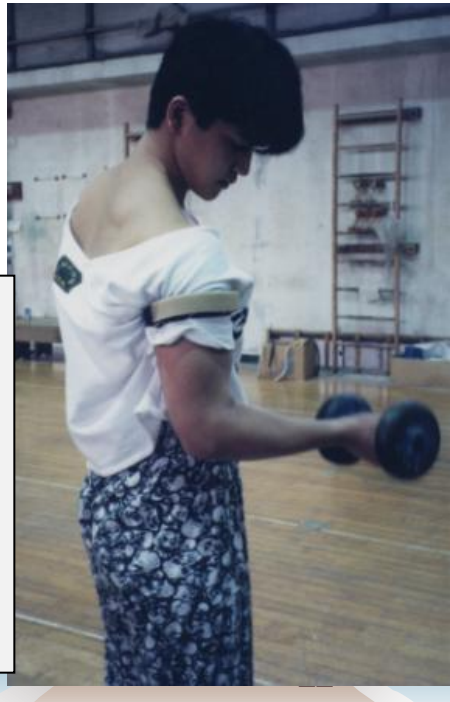
pressure: ~110 mmHg

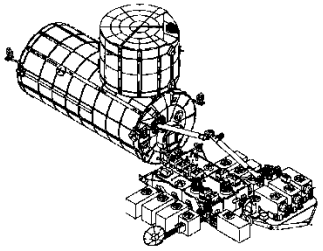
Intensity: 30-50% 1RM

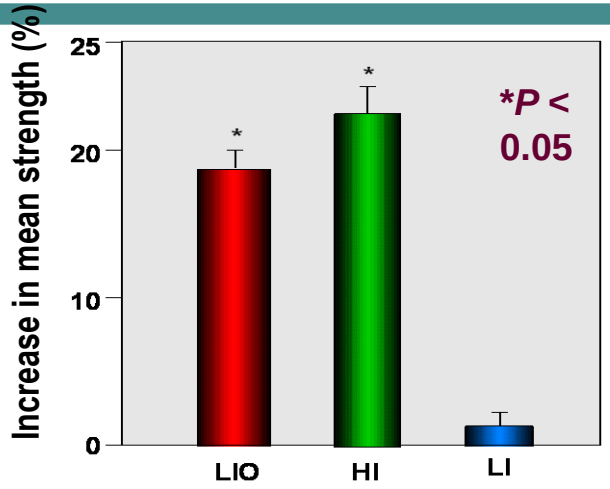
Volume: ~15 reps.

Frequency: 2 / week

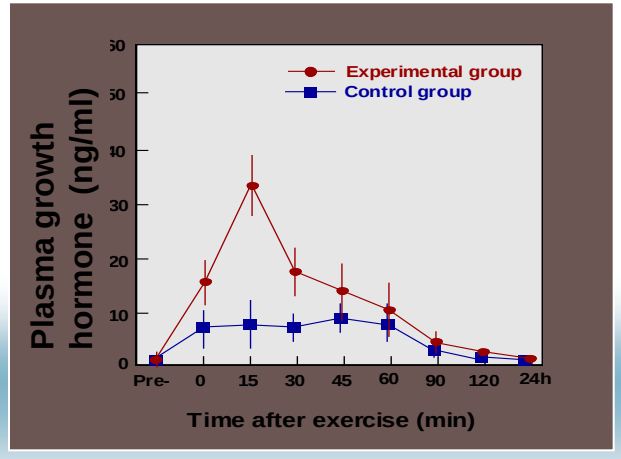
Period: 4 months







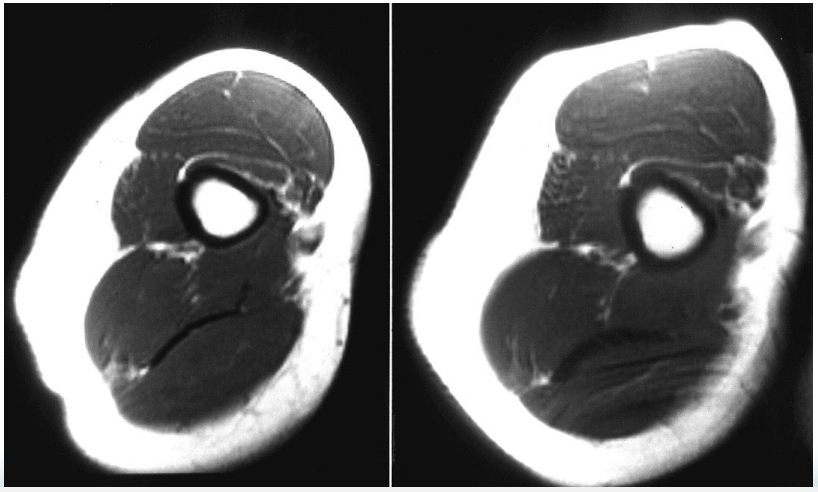
Increase in strength after KAATSU training



Increase in plasma GH after KAATSU training

Subject: 60 years-old female
Mean pressure: ~110 mmHg
Exercise regime: Dumbbell curl
30-50%1RM X 15 reps X 3 sets,
2/week, 4 months

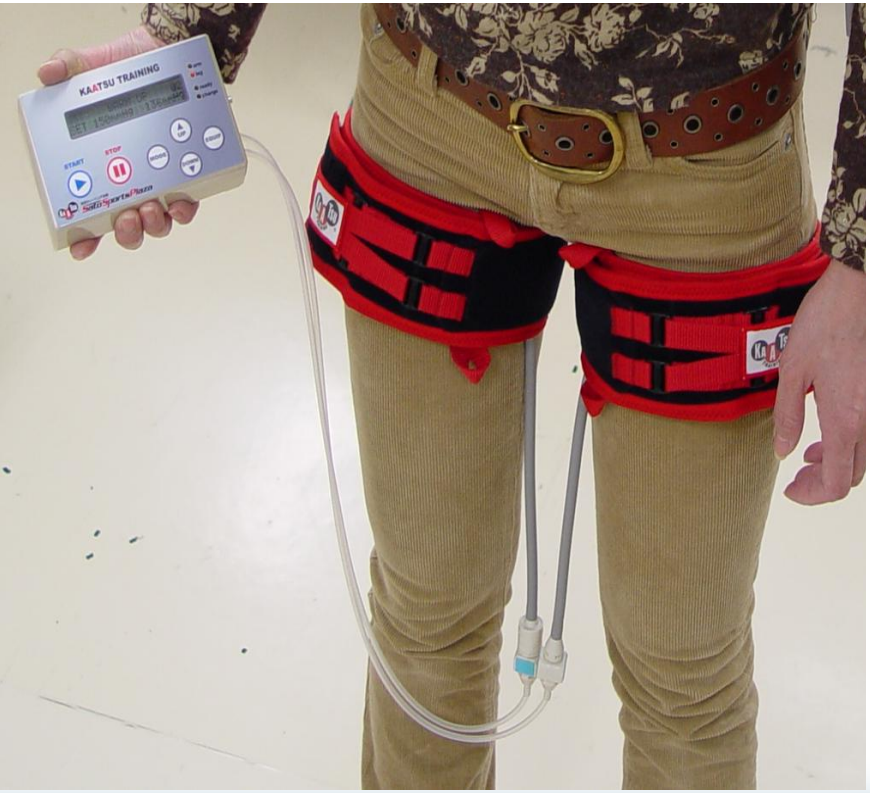
Pre-training **Post-training**



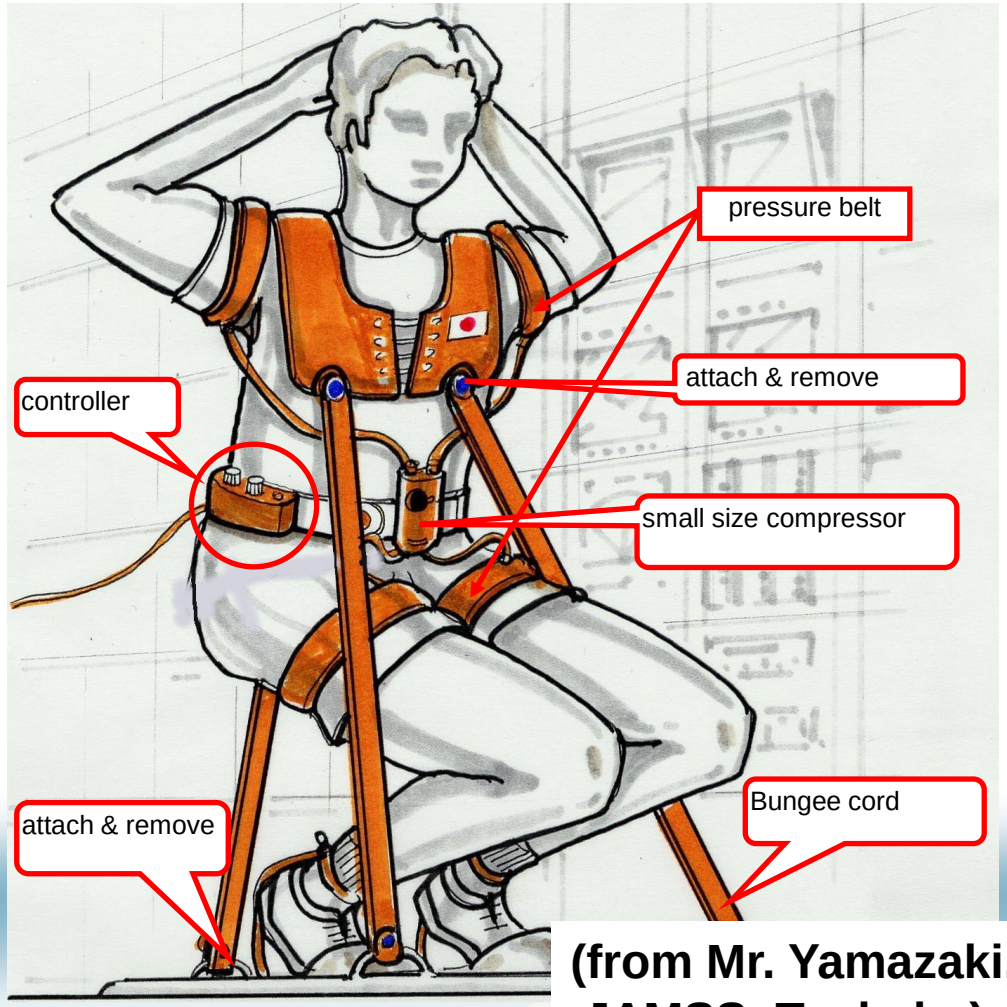
Muscular hypertrophy induced by KAATSU training

(from Prof. Ishii, Tokyo Univ.)

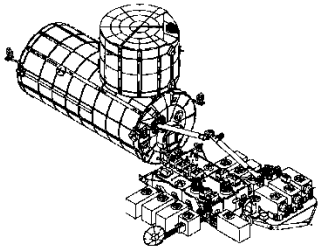
KAATSU training for future CMT R&D



Prototype of KAATSU belts and pressure controller



(from Mr. Yamazaki, JAMSS, Tsukuba)



Space Gym Suit

JAXA 宇宙航空研究開発機構 Japan Aerospace Exploration Agency

New space gym Suit

- ａｎｔｉ　ｂａｃｔｅｒｉａｌ、ｏｄｅｒ　free，　ｓｅａｍ　ｌｅｓｓ、ve
  absorb sweat, dry quickly
- Collaboration with Tokyo Women's University, TORAY, Goldwin

ISS018E043723